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(54) **AUDIO SIGNAL PROCESSING APPARATUS**

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(58) **Field of Classification Search** 704/501, 704/219

See application file for complete search history.

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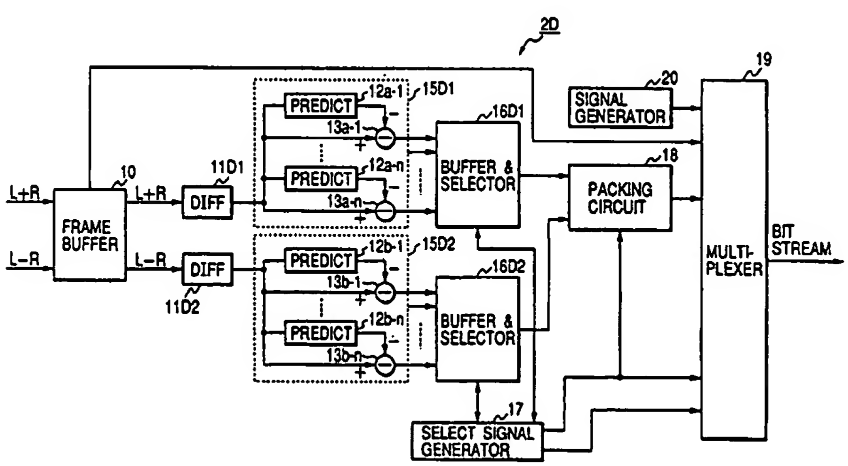
(57) **ABSTRACT**

In an audio signal encoding apparatus, a first audio signal and a second audio signal are added into an addition-result signal. The first audio signal is subtracted from the second audio signal to generate a subtraction-result signal. A first difference signal is generated which represents a difference in the addition-result signal. A second difference signal is generated which represents a difference in the subtraction-result signal. A plurality of first predictors have different prediction characteristics respectively, and are responsive to the first difference signal for generating first different prediction signals for the first difference signal, respectively. A plurality of first subtracters operate for generating first prediction-error signals representing differences between the first difference signal and the first different prediction signals, respectively. A first minimum prediction-error signal representative of a smallest difference is selected from among the first prediction-error signals. A plurality of second predictors have different prediction characteristics respectively, and are responsive to the second difference signal for generating second different prediction signals for the second difference signal, respectively. A plurality of second subtracters operate for generating second prediction-error signals representing differences between the second difference signal and the second different prediction signals, respectively. A second minimum prediction-error signal representative of a smallest difference is selected from among the second prediction-error signals.

4 Claims, 17 Drawing Sheets



APPENDIX B

"SL", the right surround signal "SR", and the low frequency effect signal "LFE" are directly applied to the lossless encoder 2F.

The lossless encoder 2E encodes the addition-result signal (L+R) and the subtraction-result signal (L−R) into a first encoding-resultant signal as the lossless encoder 2D in FIG. 1 does. Also, the lossless encoder 2F encodes the center signal "C", the left surround signal "SL", the right surround signal "SR", and the low frequency effect signal "LFE" into second, third, fourth, and fifth encoding-resultant signals, respectively. The lossless encoder 2F combines the first, second, third, fourth, and fifth encoding-resultant signals into a variable-rate bit stream representing a sequence of variable-bit-number frames. The lossless encoder 2F outputs the variable-rate bit stream to a transmission line 250.

FIG. 18 shows the format of every frame of the variable-rate bit stream outputted from the lossless encoder 2F. As shown in FIG. 18, a starting portion of every frame has a frame header. The frame header is successively followed by a first data section and a second data section. The first data section is loaded with information related to the addition-result signal (L+R) and the subtraction-result signal (L−R). The second data section is loaded with information related to the center signal "C", the left surround signal "SL", the right surround signal "SR", and the low frequency effect signal "LFE".

With reference back to FIG. 17, the lossless decoder 3F receives the variable-rate bit stream from the transmission line 250. The lossless decoder 3F divides the variable-rate bit stream into first information related to the addition-result signal (L+R) and the subtraction-result signal (L−R), and second information related to the center signal "C", the left surround signal "SL", the right surround signal "SR", and the low frequency effect signal "LFE". The lossless decoder 3F decodes the first information into the addition-result signal (L+R) and the subtraction-result signal (L−R) as the lossless decoder 3D in FIG. 1 does. The lossless decoder 3F outputs the addition-result signal (L+R) and the subtraction-result signal (L−R) to the channel correlation circuit "B". Similarly, the lossless decoder 3F decodes the second information into the center signal "C", the left surround signal "SL", the right surround signal "SR", and the low frequency effect signal "LFE". The lossless decoder 3F outputs the center signal "C", the left surround signal "SL", the right surround signal "SR", and the low frequency effect signal "LFE".

EIGHTH EMBODIMENT

FIG. 19 shows an eighth embodiment of this invention which is similar to the first embodiment thereof except for design changes indicated hereinafter.

The embodiment of FIG. 19 includes channel correlation circuits A3 and B3 which replace the channel correlation circuits "A" and "B" (see FIG. 1) respectively. The channel correlation circuit A3 includes a 1/2 divider 5*a*3 connected between an addition circuit 1*a* and a lossless encoder 2D. Also, the channel correlation circuit A3 includes a 1/2 divider 5*b*3 connected between a subtraction circuit 1*b* and the lossless encoder 2D. The 1/2 dividers 5*a* and 5*b* (see FIG. 1) are removed from the channel correlation circuit B3.

NINTH EMBODIMENT

FIG. 20 shows a ninth embodiment of this invention which is similar to the seventh embodiment thereof except for design changes indicated hereinafter.

The embodiment of FIG. 20 includes channel correlation circuits A3 and B3 which replace the channel correlation circuits "A" and "B" (see FIG. 17) respectively. The channel correlation circuit A3 includes a 1/2 divider 5*a*3 connected between an addition circuit 1*a* and a lossless encoder 2F. Also, the channel correlation circuit A3 includes a 1/2 divider 5*b*3 connected between a subtraction circuit 1*b* and the lossless encoder 2F. On the other hand, 1/2 dividers 5*a* and 5*b* (see FIG. 17) are removed from the channel correlation circuit B3.

What is claimed is:

1. An audio signal-recording disc encoded by a method which comprises the steps of:

implementing matrix operation between a first audio signal and a second audio signal to generate a first channel signal and a second channel signal correlating with each other, the first audio signal and the second audio signal relating to a same sampling frequency;

subjecting the first channel signal and the second channel signal to lossless encoding to convert the first channel signal and the second channel signal into an encoding-resultant signal from which a decoding side can reproduce the first audio signal and the second audio signal;

wherein the subjecting step comprises:

1) selecting a first sample among samples of the first channel signal for every prescribed interval of frame;

2) selecting a first sample among samples of the second channel signal for every prescribed interval of frame;

3) selecting one from first different linear prediction methods and predictively encoding the first channel signal according to the selected one of the first different linear prediction methods, wherein the first different linear prediction methods are of predicting the first channel signal from a past condition of the first channel signal <u>for every prescribed interval of subframe which is a subdivision of the frame to generate first different prediction signals for the first channel signal</u>, and generating first prediction-error signals representing differences between the first channel signal and the first different prediction signals respectively, and wherein the selected first linear prediction method generates a smallest of the first prediction-error signals;

4) selecting one from second different linear prediction methods and predictively encoding the second channel signal according to the selected one of the second different linear prediction methods, wherein the second different linear prediction methods are of predicting the second channel signal from a past condition of the second channel signal <u>for every prescribed interval of the subframe to generate second different prediction signals for the second channel signal</u>, and generating second prediction-error signals representing differences between the second channel signal and the second different prediction signals respectively, and wherein the selected second linear prediction method generates a smallest of the second prediction-error signals; and

5) generating a signal of a predetermined format having a header information area and a user data area, <u>and loading the user data area with the selected first sample of the first channel signal</u>, the selected first sample of the second channel signal, the smallest first prediction-error signal generated by the selected first linear prediction method, the smallest second prediction-error signal generated by the selected second linear prediction method, an information piece representing the

selected first linear prediction method, and an information piece representing the selected second linear prediction method.

2. A method of recording data to or reproducing data from the audio signal recording disc according to claim 1.

3. A method of network-based communication, comprising the steps of: transmitting and receiving a signal of a predetermined transmission packet format to and from a communication line, wherein the signal has been generated by an audio signal encoding method comprising:

implementing matrix operation between a first audio signal and a second audio signal to generate a first channel signal and a second channel signal correlating with each other, the first audio signal and the second audio signal relating to a same sampling frequency;

subjecting the first channel signal and the second channel signal to lossless encoding to convert the first channel signal and the second channel signal into an encoding-resultant signal from which a decoding side can reproduce the first audio signal and the second audio signal:

wherein the subjecting step comprises:

1) selecting a first sample among samples of the first channel signal for every prescribed interval of frame;

2) selecting a first sample among samples of the second channel signal for every prescribed interval of frame;

3) selecting one from first different linear prediction methods and predictively encoding the first channel signal according to the selected one of the first different linear prediction methods, wherein the first different linear prediction methods are of predicting the first channel signal from a past condition of the first channel signal for every prescribed interval of subframe which is a subdivision of the frame to generate first different prediction signals for the first channel signal, and generating first prediction-error signals representing differences between the first channel signal and the first different prediction signals respectively, and wherein the first linear prediction method selected generates a smallest of the first prediction-error signals;

4) selecting one from second different linear prediction methods and predictively encoding the second channel signal according to the selected one of the second different linear prediction methods, wherein the second different linear prediction methods are of predicting the second channel signal from a past condition of the second channel signal for every prescribed interval of the subframe to generate second different prediction signals for the second channel signal, and generating second prediction-error signals representing differences between the second channel signal and the second different prediction signals respectively, and wherein the selected second linear prediction method generates a smallest of the second prediction-error signals; and

5) generating a signal of a predetermined format having a header information area and a user data area, and loading the user data area with the selected first sample of the first channel signal, the selected first sample of the second channel signal, the smallest first prediction-error signal generated by the selected first linear prediction method, the smallest second prediction-error signal generated by the selected second linear prediction method, an information piece representing the selected first linear prediction method and an information piece representing the selected second linear prediction method.

4. A method of reproducing data which is provided via the network-based communication according to claim 3.

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